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THE SIGNIFICANCE OF PROLONGED CLINOSTATIC HYPODYNAMIA IN THE CLINICAL PICTURE OF NERVOUS DISEASES

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16. Abstract

The authors studied the character of changes of the neuro-vegetative functions during a 62-day clinostatical hypokynesis, and their relation to motor activity. The experiments were conducted with 6 normal males in the age of 23-36. At the end of the experiment there was a definite hypotrophy of the lower extremity muscles. All these symptoms had a tendency to develop with an increase of time and were much more expressed in examinees not receiving physical exercises.

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THE SIGNIFICANCE OF PROLONGED CLINOSTATIC HYPODYNAMIA IN THE CLINICAL PICTURE OF NERVOUS DISEASES

T. N. Krupina and A. Ya. Tizul

Prolonged clinostatic hypodynamia is among the questions of interest to /1008* both physiologists and clinicians. It is well known that motor activity is a necessary human biological need. Limitation of movement and the continuous influx of stimuli from receptors of afferent systems unfavorably affects functions of a number of nervous mechanisms. The complex of disorders caused by weakened afferentation during prolonged hypodynamia is combined by several authors [1] in the concept of hypokinetic disease.

Data of experimental studies and clinical observations [1-17] indicate that more or less prolonged limitation of motor activity (hypodynamia) has an unfavorable effect, primarily on the function of systems of circulation, respiration, excretion, higher nervous activity, etc. According to the data of a number of authors [5, 8, 10], after hypokinesia lasting from 5½ to 20 days adaptational reactions of the cardio-vascular system to the force of gravity (to orthostatic test) are reduced, seen as increased pulse, reduced rate of distribution of the pulse wave, drop in systolic and pulse pressure, slight anemization of the brain (dizziness), etc. The authors explain these symptoms as a functional disturbance of neuro-reflex apparatus, which regulate the activity of the cardio-vascular system, indicated by reduced strength, sluggishness and instability of cardio-vascular vegetative reflexes (Aschner, clino-orthostatic, etc.)

N. Ye. Panferova [9] has shown that during limited mobility in the majority of cases the daily rhythm of a number of vegetative functions of the body changes (temperature, pulse rate, arterial pressure, respiration, etc.). The author

*Numbers in margins indicate pagination of original foreign text.

feels that motor activity is an important component in maintaining the daily stereotype of a number of vegetative functions. Its limitation leads to a disturbance and change in the adaptational reactions which were developed during phylogeny and ontogeny.

According to the data of Yu. N. Ivanov [12], dysafferentation of the central nervous system and attendant changes in the functional state of the cerebral cortex reduce reactivity of the cardio-vascular system and respiration and disturb the activity of nervous integrating mechanisms.

L. I. Kakurin and Ye. N. Biryukov [13] observed changes in the metabolism of calcium with prolonged limitation of muscular activity which, from their point of view, can be unfavorably reflected in processes in which calcium participates (conduction of stimulation in synapses and neurons, automatism of heart muscle, etc.).

Under modern conditions, in connection with the broad introduction of technology into industry and the use of mechanized transport, when human living conditions are characterized by limitation of motor activity, study of the effect of hypokinesia on a number of neuro-vegetative functions of the body be- /1009
comes urgent from the point of view of explaining the pathogenesis of developing disorders, as well as the possibility of working out prophylactic measures.

The problem of hypodynamia is of great practical and theoretical importance from the point of view of both using the latter as an approximate model of "weightlessness" and in studying hypokinetic disorders such as possible occupationally-hazardous factors which are gaining special importance under the conditions of modern technology. In addition, the negative effect of hypodynamia on the body must also be taken into account by various clinicians with prolonged confinement of patients to bed.

Clinicians have long noted that prolonged confinement to bed of patients (prolonged clinostatic hypodynamia) unfavorably affects the course of the disease. However, it has remained unclear which disorders during prolonged con-

finement to bed are due to the disease, in connection with which the latter is prescribed, and which are the result of prolonged clinostatic hypokinesia.

We studied the character and direction of changes in the nervous system and especially its vegetative functions during 62-day clinostatic hypodynamia in 6 somatically and neurologically normal men aged from 23 to 36 years under simulated earth conditions. The subjects were placed under a strict bed regimen in a horizontal position with maximum weakening of muscles. To obtain the most complete representation of the effect of motor activity on a number of vegetative and other body functions, the subjects were separated into 2 groups of 3 men each. Subjects in the 1st group were given a physical load of a certain intensity (veloergometer for the lower extremities and a rubber expander for the upper) without disturbing the horizontal position. The subjects in the 2nd group received no physical load.

The functional state of the vegetative part of the nervous system was studied by the following tests: Aschner's eye-heart reflex, local and reflex dermographism, white spot test, measurement of pulse and respiration rate, arterial pressure, rheovasography of the extremities, etc. Also taken into account were the level of sugar in the blood, especially the sugar curve, the content of sodium and calcium salts in the blood and the condition of stomach secretion. The functional state of cortical structures of the brain were studied by electroencephalography using a 16-channel "Biofizpribor" electroencephalograph. The majority of studies were conducted before the experiment, in the first 1-2 days after its start, every 10 days during the experiment and on the 1st to 10-20th day after it ended.

We must mention that clinical examination before the start of the experiment revealed in 2 subjects (one in each group) individual symptoms of vegetative-vascular dysfunction (moderate distal hyperhydrosis, slight fluctuations in pulse rate, lability of skin-vascular vegetative reflexes, etc.).

The first clear changes in vegetative-vascular reflexes were noted in approximately the 3rd week (18-20th day) of the experiment. They appeared

as variability and instability of Aschner's reflex, local and reflex dermographism, duration of the white spot, pulse rate and arterial pressure with a trend toward steady increase of parameters of vegetative reflexes as the experiment continued. In subjects of the 2nd group, changes in parameters of vegetative reflexes began to be recorded slightly sooner than in the 1st group.

Analysis of the dynamics of Aschner's reflex throughout the experiment (Fig. 1) shows the variance in figures differed in the groups, being slightly /1010

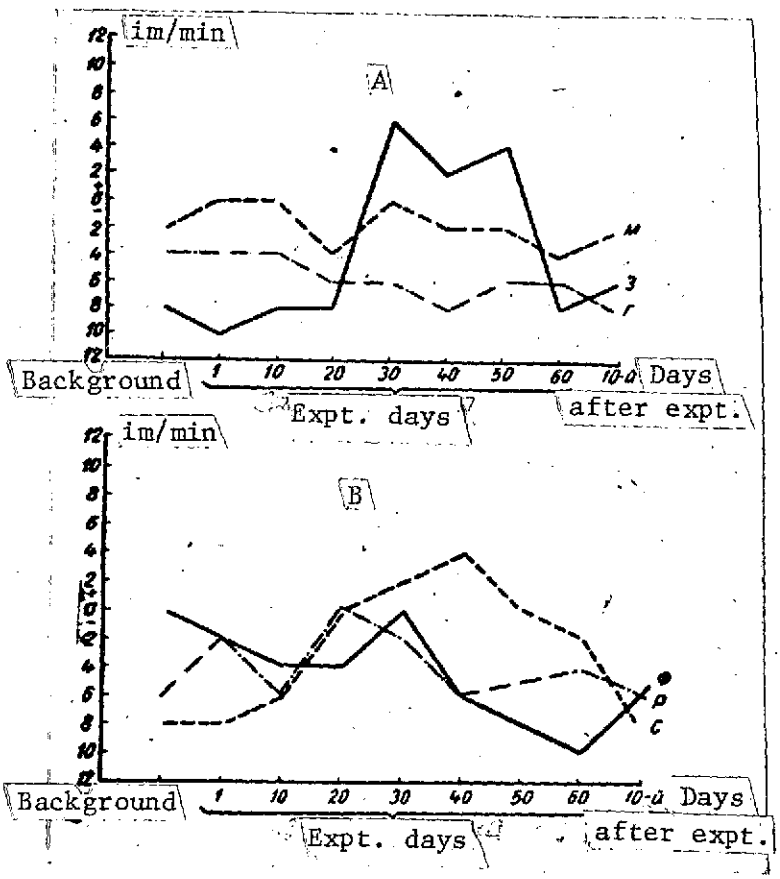

Fig. 1. Dynamics of Aschner's reflex during the experiment.
A — in subjects who received a physical load; B — in subjects who did not perform physical exercises.

greater in subjects not performing physical exercises. This difference was more pronounced during the second half of the experiment. Of the subjects in the 1st group only in Z. (in whom a background study revealed individual symptoms of vegetative dysfunction) was variance observed in indices of Aschner's reflex during the second half of the experiment, which indicated a more pronounced increase of vegetative-vascular instability.

Also differing by group were the dynamics of skin-vascular vegetative reflexes (Fig. 2 and 3). In subjects in the 1st group a trend was noted toward increased indices of skin-vascular and dermographic vegetative reflexes as the length of the experiment increased; those of the 2nd group varied from test to test and subject R. of this group (see Fig. 2) revealed pathological forms of dermographism, "elevated" and very prolonged.

The dynamics of arterial pressure and pulse rate, both having a tendency toward reduction, to some degree or other coincided with changes in vegetative-vascular reflexes and were also more clearly expressed in subjects not receiving a physical load. In subject M. of the 1st group a trend was observed toward increased arterial pressure to 140-150/90-100 mm.

In analysis of rheovasography data, constriction was noted in blood vessels of the extremities and a reduction in the tone of muscular type peripheral vessels (lengthening of the Q-T interval, smoothing out of systolic and diastolic waves). /1011

Investigation of the dynamics of the sugar content in the blood and the sugar curve revealed significant (within physiological limits) variations in indices on different days of the study. Only the coefficient of hyperglycemia changed both toward increase and toward decrease. The content of sodium in blood serum rose as the time the subjects were confined to bed lengthened, reaching maximum on the 40-50th day; the concentration of calcium did not exceed the limits of ordinary daily variations. Also noted were certain changes in the level of stomach secretion. In the first days of the experiment

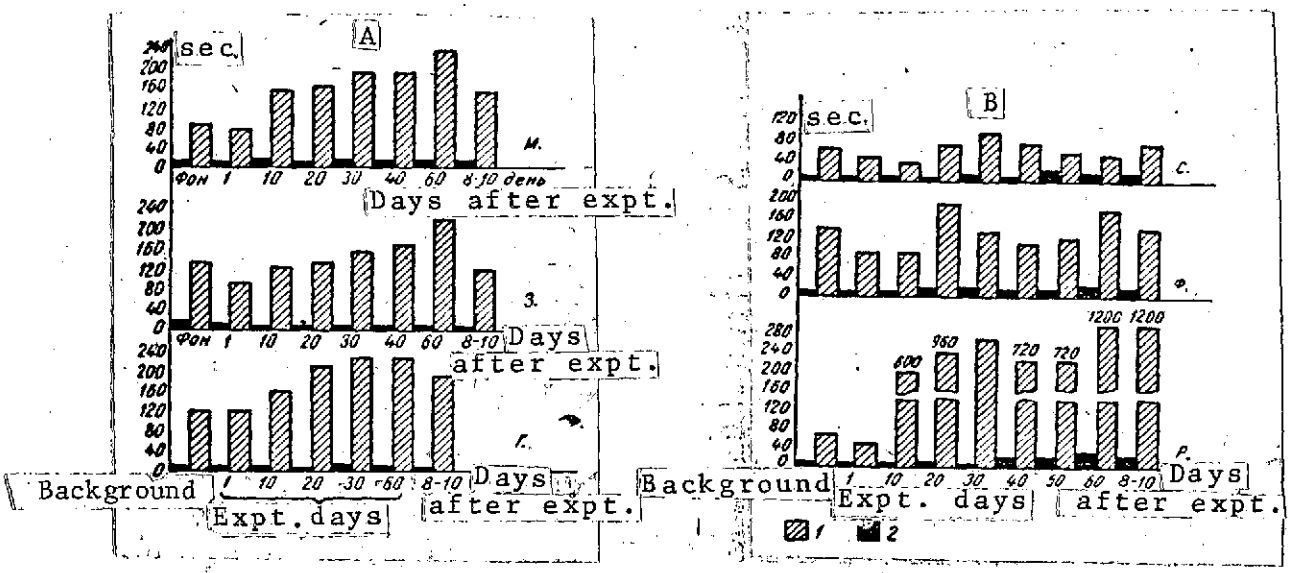

Fig. 2. Dynamics of skin-vascular (dermographic) reactions during the experiment.

1 — duration of dermographic reaction; 2 — length of latent period. Other designations same as in Fig. 1.

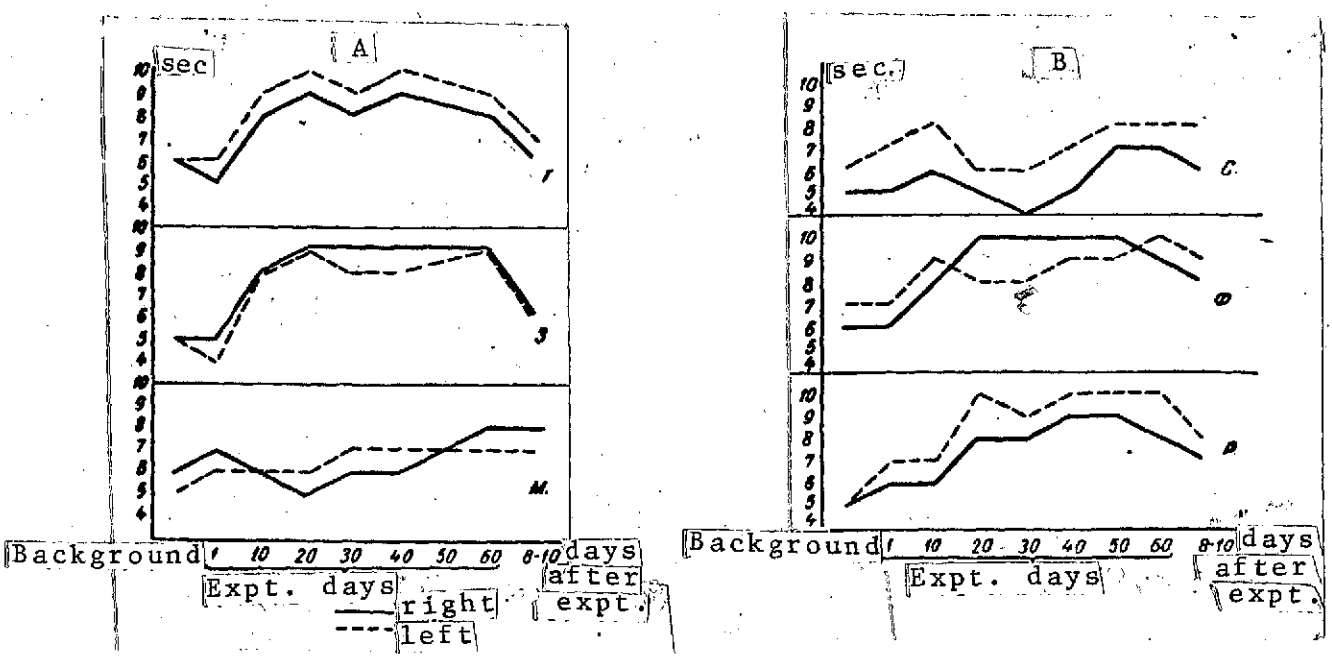

Fig. 3. Dynamics of the duration of the white spot during the experiment. Designations same as in Fig. 1.

in both groups a slight depression of secretion was observed, which by the middle of the experiment reached 45% of the original level. By the end of the experiment secretory function of the stomach showed a trend toward slight increase. /1012

The acid- and enzyme-formation functions of the stomach were also slightly altered, but differently in each group.

Along with the development of vegetative-vascular dysfunction in approximately the middle of the experiment, signs of asthenia appeared and increased as the study lengthened (increased irritability, emotional instability, rapid fatigue, insomnia, tendency to argue, etc.)

In addition, in the second half of the experiment, a clear reduction of muscular tone was recorded, greater in the 2nd group of subjects. By the end of the experiment, besides hypotonia, symptoms of hypotrophy of muscles in the calves and thighs were observed, especially pronounced in subjects of the 2nd group (circumference of the calf decreased 3-3.5 cm).

Electroencephalographic studies, made with a 16-channel "Biofizpribor" electroencephalograph from 14 points of the cerebral cortex, showed increased excitability of the cortex with maintenance of its reactivity on the first days of the experiment, progressive reduction of excitability and reactivity of the cortex and a curtailment of cortical rhythm during the development of vegetative-vascular dysfunction and symptoms of asthenia. On subsequent days of the experiment, a slight increase of excitability of the cortex was noted with low reactivity.

The majority of disorders disappeared at different times, approximately by the end of the second ten days, slightly earlier in the 1st group of subjects . Symptoms of asthenia, muscular hypotonia and hypotrophy were maintained quite a bit longer.

From the above data it is evident that with prolonged clinostatic hypokinesia various disorders result from a whole complex of pathogenetic factors acting during hypodynamia.

These data, as already noted, are of great practical and theoretical value and must be taken into consideration by clinicians of various specialties, both in predicting safety in special conditions (prolonged submarine voyages, space flights) and in prolonged confinement of patients to bed; in the latter case, along with disturbances of functions connected with certain pathological processes (cerebral insult, myocardial infarction, etc.) a number of disorders are also possible due to prolonged hypodynamia, which to a certain degree can aggravate the course of the basic disease. In connection with this, evidently, the time has come to revise radically the times which patients are confined to bed and to prescribe various sets of physical exercises earlier and more extensively.

Analysis of the changes in various neuro-vegetative functions of the body during 62-day clinostatic hypokinesia indicates that the majority of these disturbances result from certain functional-dynamic shifts, arising at different levels of the central nervous system. These shifts, from our point of view, are due to change in the level and character of proprio-interoangioreceptor and sensory afferentation, resulting from prolonged hypokinesia (change in hydrostatic pressure, gravity, partial isolation and hemodynamic disorders). Any activation or change in impulsation leads to functional changes in afferent and efferent centers of the nervous system. These changes disturb neuro-reflex mechanisms, regulating the activity of the vegetative-vascular system. Most important in the origin of the majority of vaso-vegetative disturbances, in our opinion, is functional disintegration at the level of hypothalamic structures, as it is well known that prolonged change in the level and character of afferentation in the hypothalamus leads to the development of so-called repercussive diencephalesis [18]. /1013

Changes develop first in those functional systems which to some degree or other are responsible for maintaining homeostasis. Evidently, disturbance of

a number of vegetative functions of the body which play an important role in adaptation to altered conditions of the external and internal medium [16-19, 20, 21] appear first with unfavorable effects of external factors, in particular, prolonged clinostatic hypokinesia.

Evaluation of changes by group showed that the applied set of physical exercises to a certain degree alleviates the severity and delays the onset of hypokinetic disorders. And the fact that physical exercises did not completely prevent the development of hypodynamic disturbances can indicate on one hand that the volume of physical excercises was inadequate, or on the other, that in the origin of hypodynamic disorders, changes in hydrostatic pressure and gravity are of no small importance in addition to hemodynamic disturbances.

To prevent hypodynamic disorders, along with physical exercises, it is also evidently necessary to recommend other prophylactic measures.

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